COMPOSITE SOFTBALL BAT

Field of the Invention

The present invention relates to the field of bats and more particularly to a softball bat.

Background of the Invention

For many years softball bats were made of wood. Traditional athletic bats comprised of wood are expensive and consume valuable natural resources. A disadvantage of wood bats is that they frequently break during use. A further disadvantage of wood bats is that they are exceedingly difficult to design for consistent performance, given the inconsistency of the natural material. In addition, wooden bats are made of ash or very hard pine. The sources of such woods are becoming increasingly scarce.

In the past fifteen or twenty years, softball bats made of metal were introduced. Metal bats, although more durable than wood bats, also have problems. One of the many problems associated with a metal bat is that the material is fixed and, as a result, so are the parameters of the material. Metal bats have a fixed density and a given weight. As a result, the engineering parameters that can be varied can only be varied within a limited range.

Currently, metal softball bats are more commonly used than wooden softball bats. A common structure in various non-wooden softball bats includes a hollow bat made with a handle and a hitting surface. The hitting surface includes a tubular portion and a sleeve fit inside the tubular portion. The sleeve is also made of metal. The metal bat and sleeve construction has problems. Several of the problems associated with metal softball bats having metal sleeves stems from the impact or large shock load exerted on the metal bat as a result of hitting the softball. The shock loading produces extremely large forces between the bat and the ball.

The result is that the metal bat dents when a ball is hit. In other words, the metal may dent in some form when the ball is hit. Some dents are small and some dents are large. Regardless of the size of the dent, energy is lost every hit since some of the energy is used to dent the metal rather than transferred to the softball. The dents also result in a less durable bat. Once dented, each subsequent hit is a further cold working of the metal. In some instances, a microscopic crack can also be formed as the result of denting of the bat. The crack will get bigger and bigger until the amount of material left fails due to shock loading. Many bats fail quickly. Some bats may fail after as few as twenty-five hits.

More recently, composite bats have been introduced. Composite bats include a reinforced plastic with a metal portion. For example, U.S. Patent No. 4,546,976 which issued to T.N. Jones on Oct. 15, 1985, discloses a reinforced plastic bat with a separate handle section that is softer than the hitting section. Another example is U.S. Patent No. 4,569,521 which issued to A.W. Mueller on Feb. 11, 1986, which discloses a composite bat having a tapered aluminum spar encased in polyurethane foam in order to provide stiffness and freedom from excessive vibrations. Currently, composite bats have composite shells and metal inner sleeves in the hitting portion of the bat. These bats have some of the same problems as a metal bat. In a composite bat, the metal sleeves dent over time and the impact energy that should be transferred to the ball is absorbed by denting the metal sleeve.

U.S. Patent No. 5,722,908 issued to Feeney et al. on Mar. 3, 1998, discloses a composite bat with a metal barrel, and a method of fabricating same. The bat has a frame having a recess and fabricated of a composite material of fibers in a matrix binder. A metal sleeve is inserted over the recess of the frame, which forms a hitting surface.

What is needed is a more durable softball bat. What is also needed is a bat which will not dent so that more energy is transmitted or applied to the softball. Another way of looking at this is that what is needed is a bat which will

not dent so that little or no energy is wasted denting the bat. Also needed is a bat which will not dent or be cold worked such that an inherent weak spot is formed.

Summary of the Invention

A softball bat is made entirely out of composite material. The main portion of the bat includes a substantially tubular hitting surface and a handle. A composite sleeve is added within the hitting surface. The sleeve is made of composite material. The hitting surface is also made of composite material.

Advantageously, the composite material has a lower density than metals used to make bats, such as aluminum or titanium. As a result, more material can be used resulting in a more durable bat for a given weight of bat. The composites also have a higher strength than aluminum and titanium and their alloys. Therefore, a stronger bat can be produced. In addition, the composite does not dent and therefore more energy is transferred to the ball. There is less, if any, energy wasted on denting the bat or the inner sleeve. Therefore, the inventive bat hits farther than a wooden or metal bat or bat having metal parts. The inventive bat is made entirely of composite material. Composite material can be made either more stiff or more flexible than a metal bat. The design parameters of a composite are more flexible so that either a more flexible or stiffer bat can be formed by varying the engineering parameters. The additional flexibility in using composite material allows designers to form bats with selected performance characteristics. If the bat is made to be more flexible, the inventive bat has a durability advantage since the bat does not dent and begin the somewhat slow process of failing.

Brief Description of the Drawings

Fig. 1 is a perspective view of a ball bat , with a portion of the tubular hitting surface broken away to show a sleeve according to the present invention.

Fig. 2 is a longitudinal sectional view of the ball bat of the present

invention with the end cap exploded away and showing the composite inner sleeve.

Fig. 3A is an enlarged cross section view of the present invention drawn along lines 3A-3A of Fig. 1.

Fig. 3B is an enlarged cross section view along line 3B-3B in Fig. 1.

Fig. 3C is an enlarged cross section view along line 3C-3C in Fig. 1.

Fig. 4A is a plan view of the two initial fiber socks of the bat.

Fig. 4B is a plan view of the shortened fiber sock placed over the initial sock layers shown in Fig. 4A.

Fig. 4C is a plan view of the fiber socks of the bat shown in Fig. 4B with an added hoop wrap at the tapered portion of the bat.

Fig. 4D is a plan view of the fiber socks of Fig. 4C after being covered by another sock.

Fig. 4E is a plan view of the fiber socks of the bat shown in Figs. 4A-4D with a hoop wrap added to the handle and part of the tapered portion of the bat.

Fig. 5 is an exploded perspective view of a set of sheets pre-impregnated fibers and a mandrel used to form the inner sleeve of the present invention.

Fig. 6 is a plan view of the fiber layers on the mandrel being wrapped with a layer of tape.

Fig. 7 is a cross sectional view of the mandrel with a set of sheets and three layers of tape wrapped around the mandrel.

Fig. 8 is a perspective cutaway view of the fiber layers in the sleeve.

Description of the Preferred Embodiment

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings, which form a part hereof, and in which are shown by way of illustration specific embodiments in which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

The invention described in this application is useful with all mechanical configurations of bats including softball bats and baseball bats. FIG. 1 is an exploded view of one type of a bat 100 having a substantially tubular hitting surface 110 and a handle 120. The ball bat 100 is made of composite material. The main portion of the bat 100 includes a substantially tubular hitting surface 110. A handle 120 is attached to the hitting surface. The handle 120 and barrel are integral in the bat shown in FIG. 1. It should be noted that the bat could be formed of a separate handle 120 and tubular hitting surface or barrel 110. The tubular hitting surface 110 and the attached handle 120 form the body 140 of the bat. The diameter of the handle 120 is less than the diameter of the tubular hitting surface 110 and therefore the body 140 of the bat includes a tapered portion 114 which is positioned between the handle 120 and the tubular hitting surface 110. A composite sleeve 112 is added within the body 140 of the bat and more specifically within the tubular hitting surface 110.

The sleeve 112 of the bat 100 is also made of composite material. Therefore, both the hitting surface 110 and the sleeve 112 are made of composite material. The inner sleeve 112 fits inside the hitting surface 110 of the bat 100. The inner sleeve 112 is made of a composite material which includes a fiber and a resin. The fibers can be made of Kevlar, graphite, carbon, boron, rayon, nylon, fiberglass, other plastics or other polymer materials. Graphite nano tubes may also be used. The resin or binding material may include thermosetting resin systems, epoxies, ceramics, or thermoplastics. The fibers are impregnated with a resin to form a composite material. A plug 130 is molded to the free end of the hitting surface 110. The plug 130 is typically molded into the free end of the bat 100 using a separate process.

FIG. 2 shows the bat 100 assembled and partially cut away along the length of the bat 100. The sleeve 112 is positioned within the substantially tubular hitting surface 110. In other words, the barrel of the bat is hollow. In the embodiment shown, the sleeve 112 is placed so that it tightly fits within the barrel or

tubular batting surface 110. The plug 130 is also molded into the free end of the bat 100. The bat 100 is formed and made according to a resin transfer molding process.

The body 140 of the bat 100 is comprised of a continuous resin matrix reinforced with a plurality of circumferentially-extending fiber socks 324, 326, shown in Figs. 3A, 3B, 3C and 4 and two hoops 340, 342. In the preferred embodiment, the resin components consist of Epic S7311 part A and part B available from Epic Resins of Omera, Wisconsin, although other resin components may be used in alternative embodiments. Also, in the preferred embodiment the fiber socks 324, 326 are cross woven and are comprised of 74% glass fiber and 26% carbon fiber, by weight. Of course, other types of weaves and other fibers may be used in alternative embodiments.

This particular combination of resin components and fiber socks 324, 326 results in a high-strength yet flexible body 140. When a ball impacts the bat 100 during the batter's swing, the bat undergoes a localized deformation conforming to the contact area of the ball, as well as radial or hoop deformation (i.e., the cylindrical bat temporarily deforms into an oval when viewed in cross section). This deformation provides a springboard or trampoline effect which further enhances the hitting zone of the bat 100 and provides maximum velocity to the ball when hit by the bat. The trampoline effect provides distance to a particular hit.

In the preferred embodiment, three fiber socks 324 a fiber sock 326 and two hoop wraps 340, 342 are used to form the body 140 of the bat 100. The fiber socks 324 are concentrically arranged within the resin matrix of the body 140. Figs. 4A to 4E illustrate the various layers of the bat as the bat is built up. As shown in Fig. 4A, initially two fiber socks 324 are placed on a mandrel. The two fiber socks 324 cover the body of the bat . As shown in Fig. 4B, a sock 326 is placed over the handle 120 and a portion of the tapered portion of the body of the bat. The next step, shown in Fig. 4C, is a hoop wrap 340 around the tapered portion of the bat and specifically around the two socks 324 and shortened sock 326. A first hoop wrap 340 is done with carbon fiber wrap which is advanced 3/32

inches per wrap. The first hoop wrap 340 covers the tapered portion of the body 140 of the bat. The hoop wrap 340 reduces the bulk of the socks 324, 326 and provides added strength to the tapered portion of the finished bat. The hoop wrap 340 is done with carbon fiber wrap which is advanced 3/32 inches per wrap. As shown in Fig. 4D, after the initial hoop wrap 340, another fiber sock 324 is placed over the body 140 of the bat. As shown in Fig. 4E, a second hoop wrap 342 is then placed over the bat and overlaps a portion of the first hoop wrap 340. The second hoop wrap 342 is done over the handle 120 of the bat and adds strength to the finished bat. The second hoop wrap 342 over the handle 120 removes bulk from the three socks 324 and the sock 326. The hoop wrap 342 is done with carbon fiber wrap and advanced 3/32 of an inch per wrap. The three socks 324 substantially extend the entire length of the body 140 of the bat 100, while the sock 326 substantially extends the length of the handle 120 and through a portion of the taper. The tubular hitting surface 110 is also referred to as a barrel. It should be noted the number of socks can be increased or decreased depending on the design parameters.

In other words, the handle 120 and the tapered area between the barrel 110 and handle 120 are hoop wrapped about the periphery of those surfaces.

Once the fiber socks 324, 326 are placed on the mandrel and hoop wrap 340, 342 as discussed above, and the mandrel as wrapped, is placed into a mold where resin is injected into the mold. The mold is placed in a press.

After curing, the mandrel and bat is removed from the mold. The bat is cut to length. The sleeve 112 is then force fit within the barrel or hitting surface 110 of the bat.

Since the sleeve 112 is made of a composite, the sleeve also provides a trampolining effect in addition to the trampolining effect of the tubular hitting surface 110 of the bat 100. The sleeve 112 is formed of a composite which is more stiff than the composite forming the tubular hitting surface 110 of the bat 100. Like the tubular hitting surface 110, the deformation of the sleeve 112 conforms to the contact area of the ball. The deformation of the sleeve 112 results in radial or hoop

deformation where the sleeve 112 temporarily deforms into an oval, when viewed in cross section. Deformation of the sleeve 112 provides an additional springboard or trampoline effect which is in addition to the springboard or trampoline effect associated with the tubular hitting surface 110 of the bat 100. The trampolining effect of the sleeve 112 further enhances the hitting zone of the bat 100 and provides additional velocity to the ball when hit by the bat 100. The trampoline effect provides distance to a particular hit.

The inner sleeve 112 placed inside the barrel or tubular hitting surface 110 of the bat 100 is made out of a different materials than those used in the body 140. The sleeve 112 includes sheets of inline impregnated fibers also called pre-impregnated (some referred to as pre-preg) material. A series of sheets 500 are laid up to form the layers of the inner sleeve 112. The inner sleeve 112 is substantially cylindrically shaped.

As shown in FIG. 5, the sleeve 112 is formed by placing the series of four sheets 500 on a cylindrical mandrel 520. There are four layers of lay up which form the series of sheets 500. Two of the layers 501, 502 are at plus or minus 45 degrees. The layer 503 is at 90 degrees and the last layer 504 is at 0 degrees. The fibers within the impregnated or pre-impregnated material are at 0 degrees when they are substantially aligned with a longitudinal axis 522 of the mandrel 520 or a longitudinal axis of the cylinder of the sleeve 112. The fibers within the impregnated or pre-impregnated material may also be said to be at 0 degrees when they are substantially aligned with an axis of the bat 100 running from the center of the tubular end 110 to the center of the handle end 120. The four layers 501, 502, 503, 504 are E-glass fiber impregnated with resin. It should be noted that the sheets 501, 502, 503, 504 can also be any fiber and resin system. It should be noted that the layup angles can change as well as the number of layers and still be within the scope of the invention. For example, in some embodiments layers 501 and 502 may be included in a single sheet.

After the four sheets of pre-impregnated material are placed onto the

mandrel, three layers of tape are placed on the four layers of pre-impregnated material as shown in FIGs. 6 and 7. The three layers of tape keep the four layers of pre-impregnated material 501, 502, 503, 504 tight, to remove voids and remove air pockets. The first layer 601 of tape is a polypropylene tape that is put on with a lead, with a force on the leading edge of approximately 12 to 13 pounds. The first layer 601 of tape is 5/8" wide. The first layer 601 of tape is wound over the four layers of pre-impregnated material with 3/64" of feed and 37/64" overlap. The first layer 601 of tape is actually put on in order to provide a release layer for the sleeve 112. The first layer 601 of polypropylene tape is available from any composite material suppliers.

After the first layer 601 of tape is placed on the mandrel, a second layer 602 and a third layer 603 of nylon tape are then placed on the mandrel over the first layer 601. The second layer 602 and third layer 603 are nylon tape which provides more pressure which in turn makes a stronger part. The second layer 602 and third layer 603 of nylon tape are available from any composite material suppliers. The second layer 602 and the third layer 603 are each wound onto the previous layer of tape in a similar way as the first layer 601. The second layer 602 and the third layer 603 are wound over the four layers of pre-impregnated material and the first layer 601 with 37/64" of an overlap. The second layer 602 and the third layer 603 nylon tapes are also 5/8" wide. The force on the leading edge of the tape is increased for the second layer 602 and the third layer 603 to 15 pounds of lead pressure or pressure on the leading edge. These second layer 602 wrap and the third layer 603 wrap provide strength to the backing and removes any voids and any air pockets that might weaken the sleeve 112 as formed. The second layer 602 and the third layer 603 generally strengthens the bat sleeve 112.

The arrangement on the mandrel 520, including the layers 501, 502, 503, 504 of pre-impregnated material is then placed into an oven where it is cured for approximately three hours to ensure that the final product is cured. It is recommended that the curing take place for an hour on the pre-impregnated fibers,

but curing is done for three hours just to make sure that the sleeve 112 is fully cured. After curing, the sleeve 112 is removed from the mandrel 520. The tape 601, 602, 603 is then removed by merely cutting it off with a utility knife. The first layer 601 polypropylene tape on the inside of course provides a release agent so the layers 601, 602, 603 release very easily from the sleeve.

Fig. 8 is a perspective cutaway view of the fiber layers in the sleeve. The perspective cutaway view of the sleeve 112 shows the various directions of the individual layers 501, 502, 503 and 504 within the cured sleeve 112.

The next step is to grind off enough of the exterior of the sleeve 112 so that it can be force fit within the barrel or the tubular hitting portion 110 of the bat 100. Even though the sleeve 112 is force fit within tubular hitting portion 110 of the bat 100, the outer skin or tubular hitting surface 110 is able to flex and bend and elastically deform and act like a springboard or trampoline for the ball. The sleeve 112 also provides a trampolining effect. In addition, the sleeve 112 provides strength and endurance for the shock loading associated with hitting the ball. The sleeve 112 helps launch the ball. Others may describe the bat 100 as having the capability of giving the ball "pop" upon a hit.

It should be noted that there are many different ways to configure the fibers within the body 140 and within the sleeve 112. One idea is to configure the fibers within the body 140 and within the sleeve 112 so that the vibrational nodes associated with hitting a ball with the bat are away from the handle 120 of the bat. In other words, the fibers within the body 140 and within the sleeve 112 may be changed to tune the bat 100 so that when a user hits the softball at various positions on the tubular hitting surface 110, the vibrational nodes would not be in the handle 120 of the bat. If the vibrational nodes can be moved from the handle 120, then there would be little or no "sting" or the vibration transmitted to the user's hands.

Of course, different lay-ups of materials can be used in forming the sleeve 112. Furthermore, different types of materials can be used in forming the body 140. Changing materials or the angles of the fibers within the bat and sleeve

are considered within the invention. Changing the shape of the bat 100 or using a different backing for the sleeve have also been contemplated.

It should also be noted that the body 140 of the bat 100 could be made with a composite barrel or hitting surface 110 and the handle 120 and taper could be made of another material such as metal. A sleeve 112 could then be placed within the barrel or hitting surface 110 and this would still be within the scope of this invention. Although the preferred embodiment describes the entire body 140 of the bat 100 made of composite, it is contemplated that the tapered portion of the body 140 and the handle 120 of other material could be substituted and be within the scope of this invention where the hitting surface 100 of composite includes a composite sleeve 112.

Advantageously, the composite material has a lower density than metals used to make bats, such as aluminum or titanium. As a result, more material can be used resulting in a more durable bat for a given weight of bat. The composites also have a higher strength than aluminum and titanium and their alloys. Therefore, a stronger bat can be produced. In addition, the composite does not dent and therefore more energy is transferred to the ball. There is less, if any, energy wasted on denting the bat or the inner sleeve. Therefore, the inventive bat hits farther than a wooden or metal bat or bat having metal parts. The additional flexibility of the composite material forms a bat with higher performance which hits better. Furthermore, the inventive bat has a durability advantage since the bat does not dent.

It is to be understood that the above description is intended to be illustrative, and not restrictive. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.